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ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION

Laboratory Evaluation of Wax and Silicone for Water Harvesting on Coal Mine Spoil

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New Mexico coal mine spoil treated with either silicone or wax developed water-repellent crusts; the wax crust withstood disturbance better and retained more repellency. Increasing the application rate generally improved performance of both crusts. Both treatments appear suitable for harvesting water to aid plant establishment on coal mine spoil.

Keywords: Revegetation, reclamation.

Currently in the Southwest, water harvesting is used to augment water supplies for livestock or wildlife. The practice generally consists of treating or covering the soil surface on a small watershed (less than 1 ha) to increase and collect runoff. A variety of materials have been used: salt, plastic sheet, and sprayed asphalt (Aldon and Springfield 1975, Myers 1967, Rauzi et al. 1973), butyl-sheet and wax (Aldon and Springfield 1975, Fink et al. 1973), and water-repellent chemical sprays (Myers 1967). The treatments vary, both in harvesting efficiency and cost of installation, from the inexpensive salt treatment with low efficiency, to high-cost butyl rubber with high efficiency. Other factors such as treatment longevity, resistance to erosion, and water quality, also vary.

Selection of the wax and silicone materials in the present study was based mainly on cost and ease of application. The objective of this study was to evaluate, by laboratory methods, their use in waterproofing coal mine spoil, and to determine minimum rates of application for plant establishment work.

In scope, the study will explore in some detail the relationships between concentration and application rate of silicone since little is known about the material. Because the wax is applied as a granular product, comparisons between materials for the above parameters cannot be made.

Methods

The two materials were applied at various rates to spoil collected at the McKinley Mine near Gallup, New Mexico. The spoil material is a moderately saline (EC = 5 mmhos/cm, SAR = 10), mildly alkaline (pH = 7-8) clay with poor aggregation. The spoil is derived mainly from poorly consolidated gray shale, and contains 10-25 percent shale fragments (0.2-1 cm). A composite of several subsamples of recently mined material was passed over a 1-cm screen to eliminate any large fragments. The spoil material was placed in wooden nursery flats (17 x 19 cm), and compacted dry to a 5-cm depth. Each flat had either a wax or silicone treatment at one of several rates of application. The flats were arranged in a random manner with control flats interspersed. All treatments were replicated three times, and the results used in a regression analysis.

The containers, after treatment, were placed in full summer sun (36°C daily maximum air temperature) for 5 days. This conditioning was necessary to cure the latex binder in the silicone treatment, and completely melt the wax.

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Silicone-Latex Treatment

Four different concentrations (3, 6, 9, and 12 percent suspended solids in water) of a 3 to 1 mixture of SBR latex and silicone emulsion (Dow Corning xz8-5079) were sprayed on the spoil. The rate of application was maintained at 3 l/m^2 using a hand spray bottle. Four rates of application (1.5, 3.0, 4.5, 6.0 l/m^2) were also tested at a constant 6 percent concentration. The control flats were sprayed with distilled water at the above rates of application.

Wax Treatment

Four rates (0.25, 0.5, 1, 1.5 kg/m^2) of ground paraffin were hand scattered over the spoil samples. Five-pound slabs of paraffin (55°C melting point) were frozen, broken into pieces, and passed through a garden shredder to produce the granules (0.1-10 mm used).

Penetration Test

Penetration of the crust formed in the containers was measured by counting the number of blows from a 500 g weight (2-cm vertical travel) required to drive a steel rod (4 mm diameter) through the crust. The above method was used, rather than a conventional penetrometer, because it was better adapted to the special conditions in the flats. Ten such tests were performed at equal spaces in the containers. Results of the 10 tests were averaged within each container.

Water Stability and Crust Thickness

A 2 cm^2 piece of the crust was placed in a 50 ml stoppered vial (half filled with water) and shaken by hand until 50 percent of the crust was broken down. The number of strokes (30 cm horizontal travel) required for the breakdown was recorded for five pieces, and the results averaged within each container. This method was chosen as a simple way to evaluate the relative stability of the crusts. The average thickness (cm) of each crust piece was also recorded and averaged within containers.

Water Repellence

The treated surface was tested for water repellence by the drop disappearance method. The procedure consists of placing drops of water of uniform size (using an eye dropper) on the spoil surface and timing their disappearance.

Results

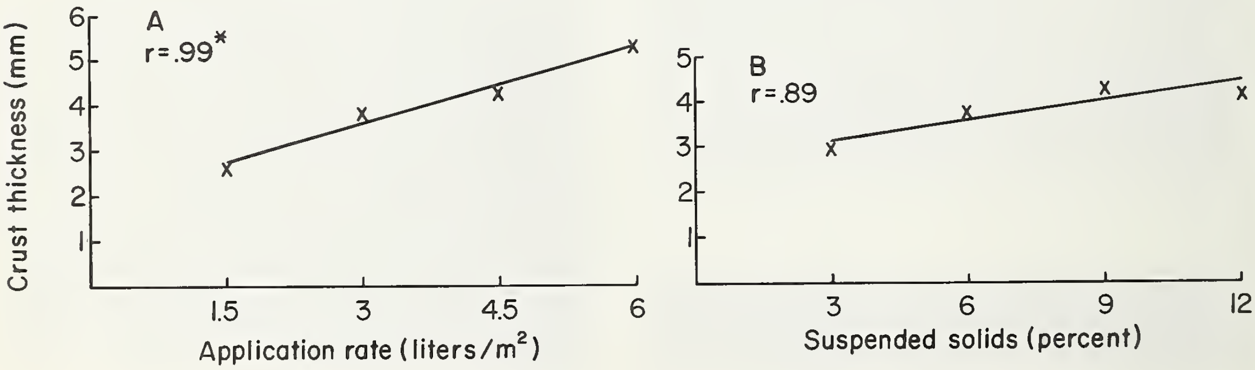
Silicone-Latex Crust

All of the silicone-latex treatments produced crusts that were significantly stronger and more water stable than the control crusts. The control crusts were also generally thinner and showed little water repellence.

Thickness.—Crust thickness was influenced mainly by the amount of fluid applied (fig. 1A). Increasing the amount of fluid undoubtedly increased the depth of penetration. As drying began, the latex binder apparently remained in place and formed crusts with thickness in proportion to fluid penetration.

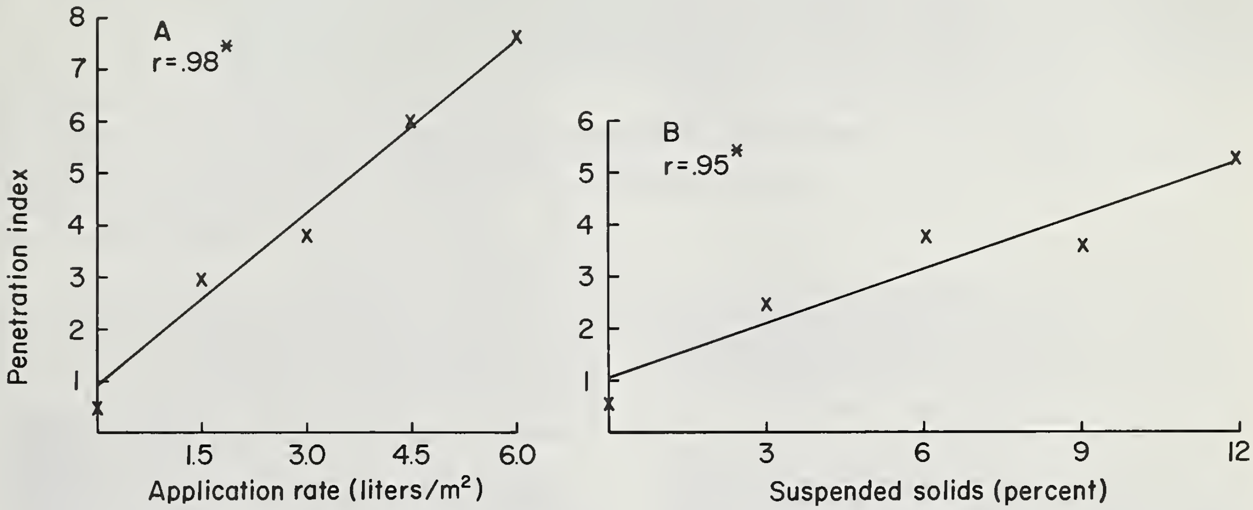
Crust thickness, however, was not greatly influenced by the concentration of the fluid at the 3 l/m^2 rate (fig. 1B), although a positive trend is shown. Depth of fluid penetration apparently is not greatly affected by concentration, at least in the range less than 12 percent.

Figure 1.—A, The influence of volume applied (6 percent suspended solids) of silicone-latex on crust thickness. B, The influence of concentration (application rate = 3 l/m^2) of silicone-latex on crust thickness.



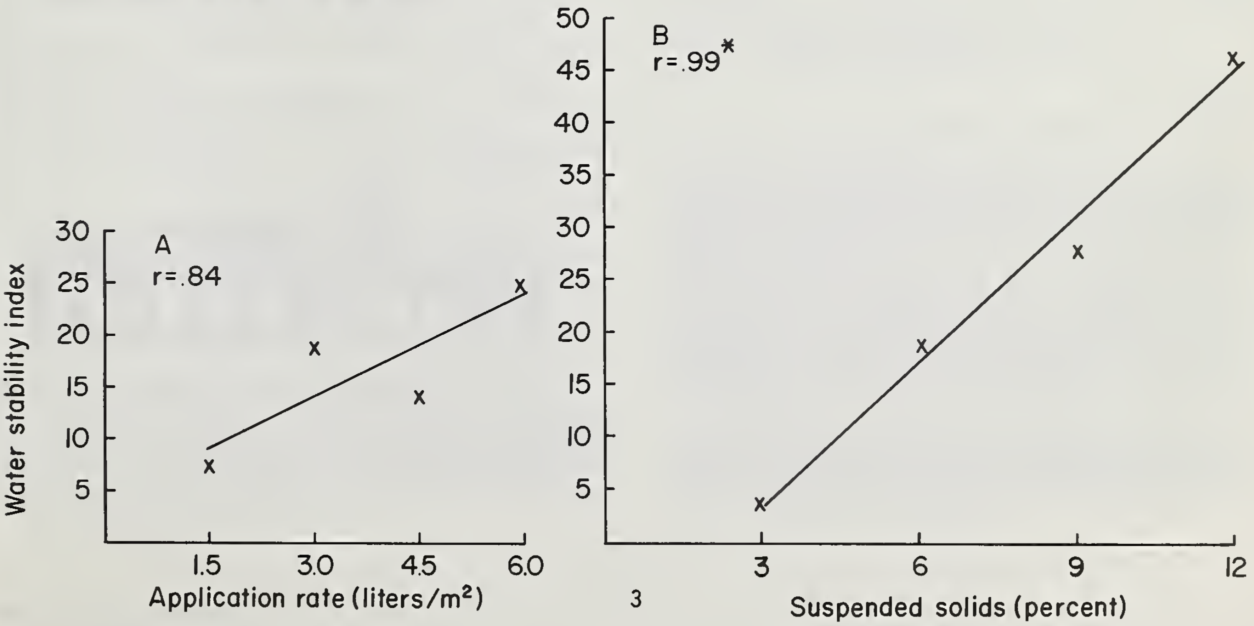
Penetration.—Both the concentration of the fluid and the rate of application affect resistance to penetration (fig. 2A, 2B). An increase in latex concentration increases crust strength at a given thickness (fig. 2B). A thicker crust, a result of high application rates, also improves resistance to penetration (fig. 2A).

Figure 2.—**A**, The influence of volume applied (6 percent suspended solids) of silicone-latex on penetration. Penetration index is the number of blows from the 500 g weight.
B, The influence of concentration (application rate = 3 l/m²) of silicone-latex on penetration.



Water Stability.—Water stability of the crust is influenced mainly by the concentration of the fluid, although increasing the rate of application does show a trend toward higher stability (fig. 3A, 3B). Increasing the fluid concentration improves water stability, while higher rates of application may not. The higher rates increase crust thickness and strength, but may not improve its water stability.

Figure 3.—**A**, The influence of volume applied (6 percent suspended solids) of silicone-latex on water stability. Water stability index is the number of times a vial, containing water and a piece of the crust, is shaken to produce appreciable crust breakdown.
B, The influence of concentration (application rate = 3 l/m²) of silicone-latex on water stability.



Water Repellence.—There were no significant differences in water repellency of undisturbed crusts at the different rates of application (47-55 minutes for drop disappearance). All concentration levels greater than 3 percent were grouped together at 55-60 minutes. The 3-percent level was significantly lower (7 minutes).

If the crusts were fractured with a sharp instrument, however, water repellency changed drastically. Drops placed over a fracture (2 mm wide) were immediately absorbed. In cross section, the fractured crusts showed water repellence only on the upper portion (1-2 mm). The loss of repellency with fracturing was most pronounced at the lower concentration and application rates.

Wax Crusts

Wax did not form a continuous rigid crust at any of the rates used. At all application rates, however, wax-treated spoil became completely water repellent (water drops disappeared only by evaporation). Considerable mixing with untreated material was needed to produce water absorption.

Comparisons of thickness, stability, and penetration of the wax "crusts" with those of the silicone were not made. Obviously, these factors were not as well correlated with water repellence in the wax case as in the silicone. There were, however, some obvious changes in the wax "crust" with increasing rate of application. The lowest rate (0.25 kg/m^2) produced only occasional soft lumps in the treated layer, while the highest rate (1.5 kg/m^2) produced an almost continuous soft crust. With the granule size used, the two lower rates did not completely treat the surface. Untreated spots occurred around some of the larger granules. Better surface coverage would have been possible with finer material. Wax penetration in the spoil varied from 0.8 cm (lowest rate) to 2 cm (highest rate).

Conclusions and Recommendations

Silicone-Latex

Both strength and water repellence of crusts are influenced by concentration and rate of application; increasing either improved the performance of the crust. Concentrations lower than 6 percent suspended solids sprayed at 3 l/m^2 are not recommended. Lower concentrations will likely produce poor water repellence and thin, fragile crusts. Since both cost and service life increase with higher rates and concentrations, specific requirements must be considered. Where water harvesting is needed only for a short time (plant establishment), a minimum rate of 6 percent solids sprayed at 3 l/m^2 should suffice.

Service life at the above rate may be restricted, however, to only the first growing season. This conclusion comes from a related study at the mine site where the above treatment (under field conditions) failed completely after 1 year.

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Wax

Strength and water repellence were not greatly affected by various application rates of wax. Water repellence was significantly better at all rates than any of the silicone-latex treatments. Although the wax crusts lacked strength compared to silicone-latex, they retained their water repellence under mechanical disturbance.

Rates lower than 0.5 kg/m^2 are not recommended because of poor surface cover and shallow penetration. Surface cover could be improved at these rates with finer grinding and careful distribution. The 0.5 kg/m^2 rate should be quite acceptable for plant establishment work during the first growing season.

In the companion study at the mine site, the wax treatment (0.5 kg/m^2) had 20 percent of the original surface intact after 1 year of field exposure.

Literature Cited

Aldon, Earl F., and H. W. Springfield.
1975. Using paraffin and polyethylene to harvest water for growing shrubs. Proc. Water Harvesting Symp., Phoenix, Ariz., March 26-28, 1974. ARS W-22, p. 251-257.

Myers, Lloyd E.
1967. Recent advances in water harvesting. J. Soil and Water Conserv. 22(3):95-97.

Fink, D. H., K. R. Cooley, and G. W. Frasier.
1973. Wax treated soils for harvesting water. J. Range Manage. 26:396-398.

Rauzi, Frank, Merle L. Fairbourn, and Leland Landers.
1973. Water harvesting efficiencies of four soil surface treatments. J. Range Manage. 26:399-403.

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